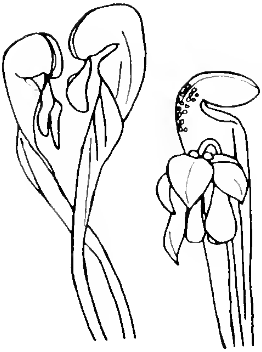
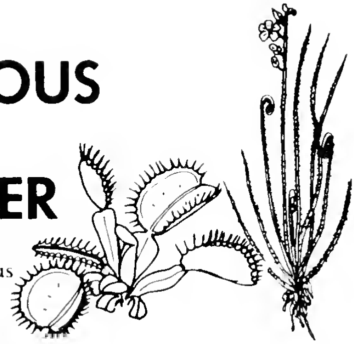
CARNIVOROUS PLANT NEWSLETTER

VOLUME 10, Number 3 SEPTEMBER 1981



CARNIVOROUS PLANT NEWSLETTER

Official Journal of the International Carnivorous Plant Society



Volume 10, Number 3
September, 1981

COVER

A form of *N. mirabilis* with a dark red undersurface of lid. For more details, please see article "*Nepenthes mirabilis* in Australia" by Dr. Peter S. Lavarack, beginning on page 69. Photo by author.

The co-editors of CPN would like everyone to pay particular attention to the following policies regarding your dues to the ICPS.

All correspondence regarding dues, address changes and missing issues should be sent to Mrs. Kathy Fine, c/o The Fullerton Arboretum, Dept. of Biology, California State University, Fullerton, CA 92634. DO NOT SEND TO THE CO-EDITORS. Checks for subscriptions and reprints should be made payable to CSUF FOUNDATION-ARBORETUM.

All material for publication, comments and general correspondence about your plants, field trips or special noteworthy events relating to CP should be directed to one of the co-editors. We are interested in all news related to carnivorous plants and rely on the membership to supply us with this information so that we can share it with others.

Views expressed in this publication are those of the authors, not necessarily the editorial staff.

Copy deadline for the December issue is November 1, 1981.

CO-EDITORS:
D. E. Schnell, Rt. 4, Box 275B, Statesville, NC 28677
J. A. Mazrimas, 329 Helen Way, Livermore, CA 94550
T. L. Mellichamp, Dept. of Biology, UNCC, Charlotte, NC 28223
Leo Song, Dept. of Biology, California State University, Fullerton, CA 92634

Seed Bank: Patrick Dwyer, St. Michael's Episcopal Church, 49 Killean Park, Albany, NY 12205, USA.

BUSINESS MANAGER: Mrs. Kathy Fine, c/o The Fullerton Arboretum

PUBLISHER: The International Carnivorous Plant Society by the Fullerton Arboretum, California State University, Fullerton, CA 92634. Published quarterly with one volume annually. Printer: Kandid Litho, 129 Agostino Rd., San Gabriel, CA 91776. Circulation: 728 (166 new, 562 renewal). Dues: $10.00 annually, $15.00 foreign. Reprints available by volume only.

International Carnivorous Plant Society
SEED BANK
July 27, 1981
$.75/packet

Byblis liniflora (12)
Darlingtonia californica (15)
Dionaea muscipula (15)
Drosera arcturi
D. auriculata (6)
D. binata v. multifida (2)
D. burkeana (1)
D. burmannii (Taiwan) (3)
D. capensis
D. capensis (narrow)
D. capillaris
D. capillaris (long leaf) (15)
D. dielsiana (1)
D. filiformis filiformis
D. intermedia
D. macrophylla (1)
D. montana
D. natalensis (3)
D. peltata (4)
D. rotundifolia
D. rotundifolia (Oregon) (10)
D. spathulata (Formosa type) (1)
D. spath. (Kansai type)
D. spath (Kanto type)
Nepenthes gracilis
N. khasiana
N. mirabilis
N. rafflesiana
Sarracenia flava
S. flava (heavy vein)
S. leucophylla
S. minor
S. psittacina
S. purpurea purpurea
S. purpurea venosa
S. flava × purp. (2)
S. leuco. × flava (15)
S. ((purp. × leuco.) × leuco.) × leuco.) (5)
S. mix
Utricularia subulata (2)

DONORS
July 9, 1980 — July 27, 1981
65 Donors 5371 Packets

P. Tsang 1006, D. Schnell 770, W. I. P. 755, E. Weiss 500, J. van Heeringen 440, S. Cole 190, J. van Dyke 130, R. Gardner 125, S. Ishisaka 93, S. Albert 70, F. Howell 62, M. Depaz 61, G. Ashley 60, J. Mazrimas 60, D. & R. Shivas 60, D. Burden 53, H. Otani 53, M.Studnicka 53, B. Carroll 50, P. Thomas 50, K. O'Connell 45, T. Burfield 41, A. Fredrickson 40, C. Owens 40, S. Hugentobler 31, R. Determann 30, J. Marabini 30, D. Taylor 30, T. Johnson 27, A. Finick 25, R. Humble 25, J. Shearon 25, S. Clancy 23, S. Clemesha 21, C. Bramblett 20, H. Dickler 20, A. Hansoti 20, S. Smith 20, J. Wexler 20, P. Riley 19, T. Carow 17, R. Matthes 17, D. Airen 15, C. Schon 15, D. Butler 14, B. Nash 12, W. Cook 10, J. de Kanel 10, A. Walter 10, J. M. Williams 9, M. Cheek 7, W. Mrazek 6, J. Griffin 5, A. Horvath 5, P. van Develde 5, D. Handley 4, M. Nathanson 4, G. McQuate 3, R. Riedl 3, R. Phillips 2, M. Beer 1, J. Grothaus 1, A. Haft 1, E. Junkel 1, R. Naczi 1.

SPECIAL ANNOUNCEMENT

No early renewals. We are unsure if there will be any price change at this time. Please wait until you receive your renewal notice with the December issue.

FOR THE RECORD

Due to an oversight, Larry Mellichamp's name was misspelled in the byline for his article for the Horticulturist's Corner. We sincerely regret the error.

News and Views

BILL BARNETT (408 Fell St., San Francisco, CA 94102) reports: I work in a large indoor plant nursery in San Francisco. We always strive to bring in the exotic and unusual plants, but the owner was not prepared for the shock of what he found last autumn. While buying at a large wholesale grower near here, among the rows of *Ficus* trees, he spotted a cart piled with pots of *Nepenthes alata*. It seems the research department of the nursery had "toyed" with the idea of raising these plants commercially but had ruled against the idea and were now ready to dispose of them.

There were 70 plants growing in pure peat moss in 8-inch plastic hanging baskets. The pots were apparently grown on a drip-irrigation. Despite the dense medium, the lack of drainage and a massive accumulation of salts, the plants were in pretty good shape. We sold over half the plants now but we warn each customer that this is not an average house plant.

The shop also maintains a small cut flower stand on the sidewalk. One day I was stunned when I arrived at work to find a vase of cut *Sarracenia leucophylla* pitchers among the carnations and gladioli. The wholesaler received the pitchers from South Carolina. The pitchers drew quite a lot of attention from the public but were not big sellers. I guess the apparent lack of popularity of the cut *Sarracenia* foliage must have something to do with its unromantic image. I mean how many people would have the nerve to present a boquet of carnivorous plants to their sweethearts?

T. W. BROKENBRO (14 Hood Road, Rainham, Essex RM13 8AS Great Britain) sends us the following: My *Drosera regia* plant which I grew from seed is flowering well at present and has in fact over the past few weeks sent up another flower spike and what looks like completely new growth from the bottom of the plant. The flowers are similar to *D. capensis* in shape and color but are much larger. The flower spikes are sticky all over and I do not know if they have digestive powers but they can certainly catch and hold smaller insects.

TIMOTHY P. BURFIELD (5 Grove St., Unley Park, South Australia 5061) writes: In response to your special request in CPN 10(1):10, 1981: about growing *Drosera regia*, I thought I'd share with you my method for growing it. The medium I use is straight German peat moss. I pot the plants into very large pots relative to their size, so as to encourage maximum root growth. Watering is from the top, and I do this whenever the peat becomes a bit dry, but not too dry. This may vary from watering every day to every 3 or 4 days depending on the temperature. I allow the water to drain straight through. The optimum temperature would be between 20° C and 28° C (68° F to 82° F). Humidity is kept roughly at 80% at all times, and the plants receive 40-50% direct sunlight throughout the day. I found the climate in the Los Angeles (where I lived at one stage) to be very similar to the climate in my hometown of Adelaide except we have a hotter summer and less smog! My plants have a reddish tinge to the leaves,but I haven't yet attempted to propagate it. I hope to do so in the near future.

THOMAS CAROW (Singener Weg 14, 1000 Berlin 37, West Germany) reports: I am writing to you about growing *Drosera regia*. I am cultivating a few small plants which I grow in a mixture of peat, sphagnum and sand.

JEFF GOLD (13126 Anza Drive, Saratoga, CA 95070) sent us the first issue of

the San Francisco (Bay Area) CP'ER, a quarterly newsletter about CPs—$6.00 for an annual subscription.

ASHISH HANSOTI (18, Navjivan Bldg., Dattatreya Road, Bombay 400054, India) again shares some of his cultural information from his difficult area. He states he has not had the commonly reported problems with vermiculite mixes breaking down into a heavy, muck-like consistency, and some of his pottings are more than a year old. He states that if vermiculite is allowed to dry up after the first moistening, it will indeed break down. So, once the pot is watered, it must be kept continuously moist, and stored vermiculite mixes must not be allowed to become wet until ready for use. He also has noted that vermiculite mixes show very little to no salt aggregation on the surface as many other mixes do. He attributes this to possible absorption of salts into the lattice of the vermiculite particle. He has had success in germinating *Nepenthes mirabilis* seed on a mix of vermiculite and fresh green epiphytic moss (not sphagnum which is rare in his area), kept in high humidity under a plastic bag.

JOHN A. LINDQUIST (118 Bacteriology, University of Wisconsin, Madison, WI 53706) sends us this: Since completing my M.S. thesis on the microbiological observations of *Sarracenia purpurea* in 1975, I've managed to work in a few experiments while a bacteriology lab instructor at the U.W.-Madison (and a classical and old rock-and-roll DJ at a local FM station). After testing a total of 31 pitcher leaves for the presence of photosynthetic bacteria, 29 leaves were found positive, and all isolates appeared to be *Rhodopseudomonas*, most likely *R. palustris*. In the literature on plant-microbial associations, I have not read of photosynthetic bacteria being associated with plants. But as they are primarily aquatic microorganisms, their presence in any pool of water (rainwater in this case) exposed to sunlight would not be surprising.

In an experiment to quantitate coliform bacteria in five pitcher leaves by the use of standard methods for water analysis, I got presumptive total coliform counts ranging from $4.3. \times 10^3$ to 4.6×10^5/ml. Three leaves were positive for fecal coliforms with counts ranging from 0.9 to 2.3×10^3/ml. As the finding of fecal coliforms (i.e., *E. coli*) at any site is evidence of fecal contamination, I would surmise that the bacteria were brought into the pitcher leaves by means of flies.

Other bacteria of interest which have been observed in substantial numbers in pitcher water include (1) *Caulobacter* (a stalked bacterium which abounds in water containing a low concentration of organic materials), (2) *Chromobacterium violaceum* (primarily a tropical organism which has been known to cause fatal infections in man; it also produces a deep-violet pigment) and (3) a peculiar pink-pigmented bacterium which has thus far eluded attempts at its identification.

While examining the wondrous collection of bromeliads at the U.W. Botany Department greenhouse, I noted that each had collected a goodly amount of water within its rosette of leaves. The thought of flies falling in and decomposing and benefitting the plant came to mind, and while I have not proved bromeliads to be passively carnivorous, there does seem to be the microbiological potential for this to be so. I sampled wter from specimens of *Aechmea folgens*, *Bilbergia vittata* and some unlabeled poinsetta-like plants and found total baterial counts averaging 2.9×10^6/ml; the number of proteolytic bacteria averaged 4.7×10^5/ml. (Six plants were sampled from.) I could not resist testing for photosynthetic bacteria, and (sure enough!!) from the two plants tested, the counts were 4.8×10^4 and 6.8×10^5/ml. These bacteria appeared to be the same type of organism (*Rhodopseudomonas*) as found in the leaves of *Sarracenia purpurea*.

I continue to hope that someone will undertake a study of the "digestive" glands of *S. purpurea* and determine if they contribute at all to the digestion of

insects. I have tried a few experiments along this line some years back, but I was always plagued by bacterial contamination. I dislike the idea of using antibiotics, as this procedure could upset the metabolism of the plant. Raising the plants in a germ-free environment seems to be the best way to go.

WAYNE MRAZEK (2270 Grayson, Anaheim, CA 92801) replies: Enclosed is a picture of *Drosera regia*. I am cultivating two plants, one growing larger, the other apparently going dormant. I am growing them in live sphagnum moss, and have been told by a friend in England that it is as easy to grow as *D. capensis*.

GREG RUSSELL (71 Melrose Dr., Flindersview, Qld. 4305, Australia) reports: We have started a society here in Ipswich. There are twenty members at present but all are good workers. We hope to produce a newsletter to promote carnivorous plants and our club throughout Queensland. Articles such as yours would be very valuable to us if we could use them. We have put on displays for orchid clubs and we have created some interest. Through activities such as these, we should boost our membership. As the C.P.N. of Australia has fallen down (I have not had a copy since Vol. 6), maybe our newsletter will bring collectors together again.

TOM STORY (1112 Klengel St. Antioch, CA 94509) sends us a newspaper article reporting the increase in pilfering of plants from botanical and private collections. It seems that the thieves know exactly what they are after since the best and rarest orchids and carnivorous plants are taken. Many of the famous collections in Great Britain are now closed to the public or greater restrictions are imposed on visitors. In this report, the Royal Botanic Gardens at Kew reported some carnivorous plants were taken.

The Evolution of Carnivorous Plants

by D.C. Speirs
Box 6830 Stn. "D"
Alberta T2P 2E7, Canada

It would be nice to have a time machine so as to see exactly how CP evolved. None being at hand, one must turn to the fossil record, but unfortunately it is very sparse on the subject. Droseraceae pollen first appeared in the Miocene period (26 to 7 million years ago), and *Aldrovanda* is reported from the Eocene (58 mya) of south England (Raven & Axelrod 1974). There is a report of *Aldrovanda* seeds having been found in interglacial deposits of Europe (Nikitin 1927) but these are quite recent. They are identical to modern seeds and thus shed no light on the evolution of this genus.

The aforementioned fossils indicate that CP are at least as old as the Eocene but not necessarily exactly that old, as earlier fossils may not have been preserved or not yet discovered. Ancestral forms are hidden somewhere in the sediments, as CP could not suddenly appear fully-developed in their present form. These ancestral forms would not always be recognized, as they would be without definitive CP characteristics during their initial period of evolution.

Since CP are flowering plants (angiosperms), they can be no older than the Cretaceous, 135 to 75 mya, when angiosperms first began to evolve. Angiosperms diversified rapidly during the Tertiary, 75 to 2 mya, and most likely this is when CP first appeared on earth. The prey of the plants, generally insects, all precede angiosperms by up to several hundred millions of years, so no assistance can be had from them in fixing a date of CP origin.

Attempts are often made by botanists

to rank species in a phylogenetic tree based on "primitive" versus "advanced" characteristics. A number of fallacies usually detract from these attempts. Firstly, no two botanists will necessarily agree on what is primitive and what is advanced. One man's "primitive" is another man's "degenerated from advanced stock." The same characteristic of a plant can be given different weights by different botanists. One botanist may consider the characteristic to be a major part in classifying the species, while another considers it to be unimportant. Thus without a good fossil record, one cannot provide a definitive phylogenetic tree of CP, and one cannot establish such a tree based on comparisons between CPs. (Fig. 1).

When considering CP evolution, allowance must be made for the effect of continental drift as well. When angiosperms first began to evolve, there existed on this planet only two supercontinents, Laurasia and Gondwanaland. Laurasia, in the northern hemisphere, consisted of North America, Europe, and Asia. Gondwanaland, in the southern hemisphere, was formed from South America, Africa, India, Australia, and Antarctica.

Laurasia and Gondwanaland began to break apart in the Cretaceous. By the Eocene, India was an island floating north towards a collision with Asia. Africa had separated from South America. South America was still connected to Antarctica, which in turn was attached to Australia and New Guinea (fig. 2). Not until late in the Tertiary were all the continents separate from each other and assuming their present positions. The contact between North and South America was intermittant, Central America rising above and falling below water level several times throughout the Tertiary.

By considering present-day CP distribution together with continental drift, one can speculate when a particular CP family might have evolved. It seems likely, for example, that the Byblidaceae and Cephalotaceae, endemic to Australia, evolved after that continent was isolated from the others by drifting, after the late Eocene.

In the Lentibulariaceae are the genera *Pinguicula* and *Utricularia.* The latter has a worldwide distribution. It is difficult

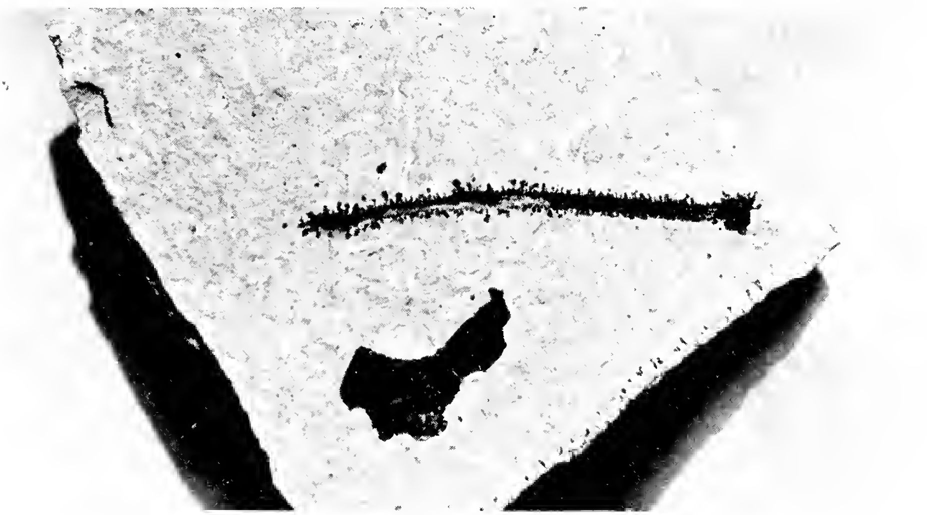


Figure 1. Unfortunately this is not a fossil *Drosera* leaf. Collected from Eocene sediments of British Columbia, Canada, it is a pine needle with dendrites (outgrowths of minerals which crystallized on the fossil needle). Paleobotanists have been fooled by less subtle pseudofossils. Photo by the author.

to say whether this is because it evolved before the supercontinents split up or because aquatic plants can be dispersed more easily than terrestrials. *Pinguicula* is confined to the northern hemisphere, with a dip into South America. It seems probable that it evolved in Laurasia during the Tertiary, and spread to South America quite recently when Central America rose.

The Sarraceniaceae are confined to North America and northern South America. Based on continental drift, they would have appeared after Laurasia broke up in the Tertiary, probably some time after the Eocene. By then North America was separated from Europe, isolated the ancestral stock and confining it to one continent. Dispersal to South America would have followed much later.

The Droseraceae are worldwide as a whole, suggesting an origin in the Cretaceous or early Tertiary, before the continents had drifted very far from each other. *Aldrovanda,* being aquatic, may have travelled with greater ease than its fellow genera. It ranges from Europe to Africa, India, Japan, and northern Australia. *Drosophyllum* is confined to the Iberian peninsula, with apparently local dispersion to Morocco, unrelated to continental drift.

Dionaea is, of course, endemic to southeastern North America. The difficulty here is to determine whether this endemism is a result of recent evolution or because the genus is a relict and formerly had a wider distribution.

Drosera is worldwide, suggesting an early origin in the Cretaceous or Tertiary.

Nepenthes is found from northern Australia to Sri Lanka and Madagascar. It may well have originated in Gondwanaland, as Australia, India, and Madagascar made up the northern coastline of that supercontinent. This suggests

Please see **EVOLUTION** page 65.

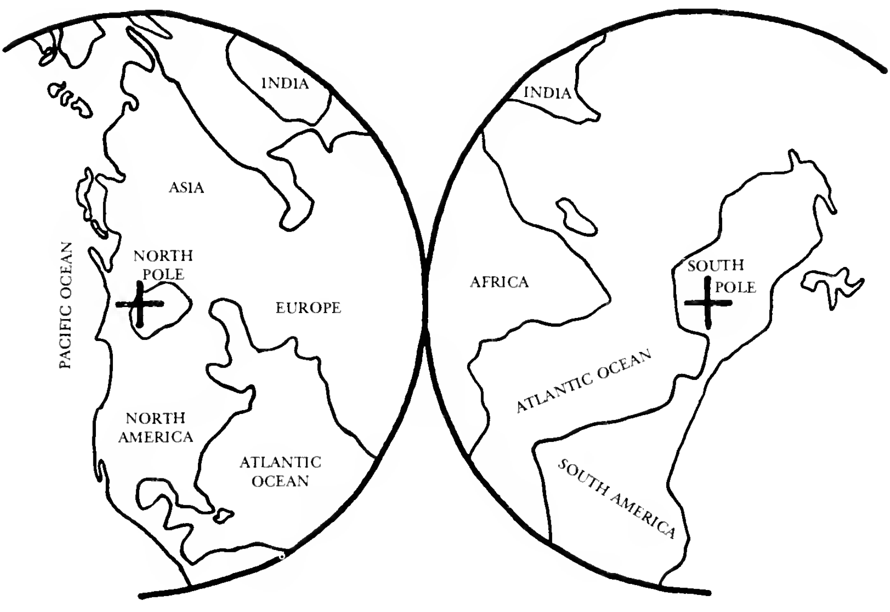


Figure 2. The world as it appeared in the early Tertiary. Northern Hemisphere is at left, Southern Hemisphere at right. Crosses indicate the poles.

HOW EXCLUSIVE ARE CARNIVOROUS PLANTS?

by Paul Simons
Department of Chemistry, Imperial College
London SW7 2AZ, England

We tend to think that carvinorous plants belong to an exclusive club. Alone amongst the rich variety of plant life, only a few hundred fungi and flowering plant species are thought to be carvinorous, and of these we are mostly familiar with the flowering CPs. It is hardly surprising — the bizarre and often highly sophisticated traps of these plants have set them far apart from anything else we know of. Or have they?

Charles Darwin (1875) suspected that many plants bearing adhesive glands might turn out to be carnivorous, amongst them *Saxifraga umbrosa, Primula sinesis, Pelargonium zonale, Erica tetralix,* and *Mirabilis longifolia*, but (uncharacteristically) he did not take his suspicions any further. Probably the most influential review of the likelihood of carnivory outside our traditional concepts was Francis Lloyd's opening chapter in his classic book *The Carnivorous Plants*, published in 1942. In this he briefly mentioned a whole host of various insect-trapping devices in a quite extraordinary range of plant species — and yet he either dismissed or passed over all of them. It is probably thanks to Lloyd that we have settled for such a meagre number of carnivorous plant species.

One outstanding problem, though, is to define exactly what a carnivorous plant is, and I'll return to this question later on. What I want to consider first is the *potential* scope for widening the carnivory membership in the plant kingdom.

Adhesive traps

One of the commonest carnivorous plant traps is the sticky leaf trap, which glues its prey down while digesting it. This type of trap is present in many flowering plants (*Drosera, Drosophyllum, Pinguicula, Triphyllum*) and also hundreds of fungal species. But there are many more flowering plants which bear sticky hairs on parts or the whole of their shoots, as pointed out by Darwin; a few examples are given in Table 1. Aha, you might say — these sticky hairs are there to protect the plant from herbivorous insect predators, particularly crawling ones. Yes, this is no doubt true, but then the same equally applies to *Drosera, Drosophyllum* et al.; the essential difference, though, is that the plants in Table 1 (and others like them) have not been properly investigated. However, this is not true for a few forgotten species.

Apart from Charles Darwin, most of the early classic scientific work was carried out by Germans, so it came as a great surprise to me to stumble upon an intriguing Italian paper in *Biological Abstracts* entitled "Ricerche anatomofisiologiche sulla *Petunia violacea* e sulla *Petunia nyctaginiflora* come piante insettivore." Even

---

EVOLUTION continued from p. 64

Nepenthes had a coastal distribution during the Cretaceous.

Having written all this, I remind the reader that the foregoing is speculative and based on the assumption that CP distribution was determined mainly by continental drift. Long distance dispersal may have played a part in the matter. One wonders though, that if *Drosera* was spread about in such a manner, why then were *Byblis* and *Cephalotus* not so affected.

REFERENCES

Nikitin, P. A. 1927. Interglacial occurrence of *Aldrovanda vesiculosa* L. New Phytologist 26:58-59.

Raven, P. H. and Axelrod, D. I. 1974. Angiosperm biogeography and past continental movements. Ann. Missouri Bot. Garden 61:539-673.

TABLE 1. Examples of sticky hairs borne on the shoots of higher plants not traditionally considered carnivorous.

Organ(s) on which hairs are borne	Example of species
Leaves	*Erica glandulosa*
Stem	*Aeonium canariense*
Whole inflorescence	*Geranium madeirense*
Leafy bracts around flower	*Platylepis glandulosa*
Pedicel, corolla and calyx of flower	*Linnoea borealis*
Ribs of calyx	*Plumbago europea*
Entire foliage	*Primula glutinosa*

with my complete lack of the Italian language, I grasped that there was something very interesting in this. A call to the Science Museum Library located the paper by Zambelli, and started a fascinating paper chase, for cited in this paper were references to two other papers on insectivory in *Martynia lutea* (Mameli, 1916) and *Lychnis viscaria* (Mameli and Aschieri, 1920). All three papers were written by botanists at the University of Pavia, in the 1910s and 1920s, and translation of salient parts of each paper* revealed that both mucilage and digestive enzymes were detected in the secretions from the hairs of all four species. Furthermore, all these species readily captured and killed insect visitors, which, at least in the case of *Martynia*, attracts midges and other detritus-feeding flies by giving off a stinking odor. Figures redrawn from the paper are shown in figure 1.

Why did Lloyd omit these investigations (and many of the other useful references they cited) from his book, particularly as his literature research appears to be otherwise exceptionally thorough? To be fair, Lloyd did cite the earlier work of Fermi and Buscaglione (1899), who found that *Martynia* and many other genera could not digest animal matter; but the answer to why he did not include the later research which superseded this reference is a mystery. What is clear, though, is that we have taken Lloyd's book as definitive of all pre-1942 work, and that the Italian work has become lost in the course of time.

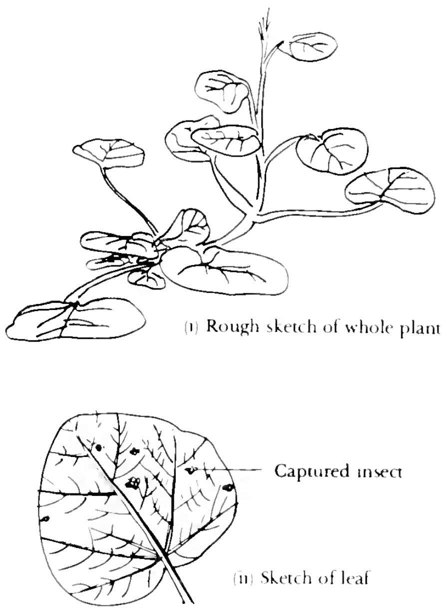
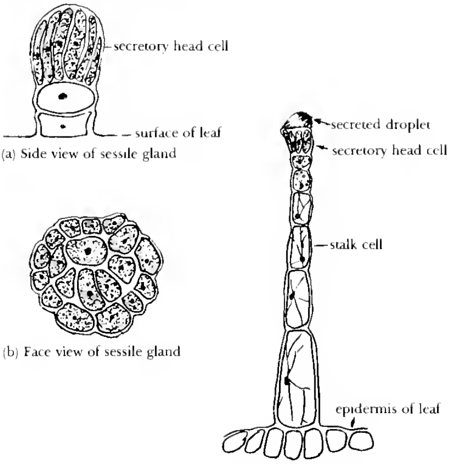


Figure 1. *Martynia lutea*

A more recent series of papers has described an even more intriguing discovery. John Barber of Tulane University, New Orleans, has shown that *seeds* of *Capsella bursa-pastoris* (Shepherd's purse), and probably most other Cruciferae seeds, behave like full-grown carnivores (refer to Barber, 1978). Not only do they trap, digest and absorb insect life, but they also release an attractant which lures mosquito larvae. The benefit to the seed's nutrition appears to be all the more important, since seeds of *Caspella* are very small, with consequently small food reserves; in addition, the germinating seedlings often

(iii) Leaf Glands (After Mameli, 1916)
(Magnification not known)



(a) Side view of sessile gland

(b) Face view of sessile gland

(c) Side view stalked gland

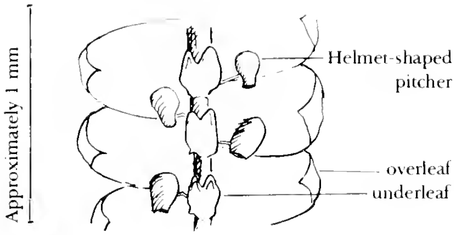
Figure 1. *Martynia lutea*

develop in nutrient deficient environments. (Perhaps the digestion of the prey also releases heat, so that the seeds germinate more readily).

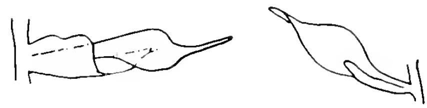
Water-holding organs

Another 'classic' carnivorous plant trap is the water-filled leaf pitcher; unwary animals are lured into them, fall in, and drown. Various types of water-holding structures are present in a wide variety of other plants, particularly in those plants having no contact with the ground but having independent means of nutrition — the epiphytes. Because of their aerial disposition, most epiphytes suffer from irregular water supplies, and have evolved various sorts of pitchers to collect and store rainwater.

Many of these water-holding pitchers are also ideal for trapping animals as well as rainwater. For example, the leaf lobes of many leafy liverworts (a group of lower plants resembling mosses) are cup-shaped, and readily catch rainwater trickling down the bark of a tree or whatever structure they are supported on. Microscopic single-celled organisms are often found swimming inside the leaf lobe pitchers, but do not seem to come to

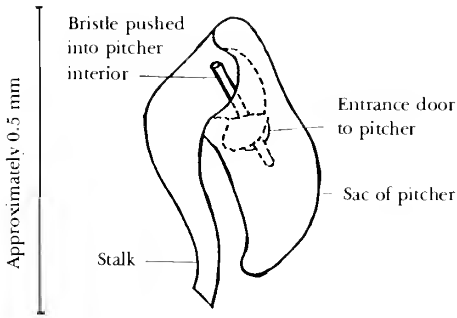


Frullania tamarisci, viewed from below
(Drawn after Watson, 1971)



Front view Rear view

Colura calyptrifolia (after Muller, K. 'Rabenhorst's Krytogamen-Flora von Deutschland, Osterreich und der Schweiz VI', Edn. 3 Lieferung 9 (1957), Akad. Verlag. Geest & Partig, Leipzig)



Leaf lobe pitcher of *Pleurozia*
(Drawn after Stephani, F., 'Hepatiques insectivores', Rev. Bryol. 13:97-99 (1886))

Figure 2. Leafy liverwort pitchers

any harm inside them. However, the leaf lobes of two largely tropical genera, *Colura* and *Pleurozia* developed into astonishingly sophisticated pitchers (figure 2). The narrow entrance to each slipper-shaped pitcher is closed off by two flaps, one of which is rigid and one which is flexible. Should an animal pass into one of these pitchers it would have to push the flexible flap inwards, but once inside the pitcher the flap would spring back and seal off the entrance. Whether minute animals are trapped in this way is simply not known, but modern authorities such as Schuster (1966) regard the function of

the pitchers as primarily for storing water, although Watkins (1971) says a carnivorous function is plausible.

Other epiphytic pitchers are generally much larger than those of the leafy liverworts, and as well as rainwater, collect dead leaves, insect carcasses, and other organic debris. Whether the animals become trapped and killed in such pitchers is not clear, even though their remains are almost certainly of nutritional value to the plant. For example, in the elaborate pitchers of *Dischidia rafflesiana* adventitious roots grow into the accumulated organic matter so as to extract useful food. Living animals are also found in many pitchers, such as in the cup-shaped leaf bases ('cisterns') of *Billbergia pallidflora* (cistern plant) (Van Oye, 1923). That most other members of the pineapple family, the Bromeliaceae, also have cup-shaped water-storing organs is certain, but some sort of symbiotic relationship with aquatic animals is quite possible.

Water-holding structures are not exclusive to epiphytes. *Dipsacus sylvestris* (the common teasel) has long been suspected of having carnivorous habits, as its leaf and flower bracts are very effective rainwater traps, often containing an abundance of insect bodies. Francis Darwin (son of Charles) noted that beetles caught in the teasel's bracts appeared to die quicker than in ordinary rainwater (F. Darwin, 1877), and Christy (1923) thought that the bract water stupefies its prey before it drowns. Unfortunately neither scientist provided more conclusive evidence for its carnivory.

There are many more water-holding devices just as likely to perform a carnivorous or 'quasi-carnivorous' function, and some of these are included in Table 2.

Another intriguing type of pitcher is that of the ant-plants, in which an ant population lives within the plant, protecting it from attack by herbivores and/or overgrowth by vines. Fred Rickson, of Oregon State University, Corvallis has recently shown that cohabiting ants of the ant-plant *Hydnophytum formicarum* actually *feed* the plant with insect remains they have previously captured, and that these remains are absorbed into the plant (Rickson, 1979). Although this type of nutrition does not strictly qualify as carnivory, since the animal food is trapped and killed by the ants (not the plant), it shows an uncanny resemblance to proper carnivory: degraded animal matter is absorbed into both types of plants. Since

Please see **EXCLUSIVE** p. 79.

TABLE 2. Examples of water-holding structures, which may also serve a carnivorous function.

Organ	Description	Examples
Leaf lobe	Cup- or slipper-shaped pitchers	*Frullania, Colura*
Pocket leaves	Rosette of leaves surrounding a funnel-shaped cavity holding water and organic debris	*Asplenium nidus*, members of the Bromeliaceae
Mantle leaves	Leaves pressed against a stem so as to be able to collect water and organic debris (into which roots grow)	*Drynaria*
Cisterns	Urn-shaped cups formed from vertical leaves	*Billbergia*
Leaf and floral bracts	Cup-shaped pitchers	*Dipsacus sylvestris*
Pitcher leaves	Hollow pitchers which collect water and organic debris (into which roots grow)	*Dischidia rafflesiana*

BOTANIST'S CORNER

Reprinted from CPN-Australia with corrections by author

Nepenthes mirabilis in Australia

by Dr. P. S. Lavarack
National Parks & Wildlike Service
Pallarenda, Townsville, 4810
AUSTRALIA

The genus *Nepenthes* contains about 70 species spread between Madagascar and New Caledonia, but with the center of distribution being the Malay Peninsula, Borneo and Sumatra. One species, *N. mirabilis,* occurs in Cape York Peninsula. It is the most widespread species in the genus occurring in New Guinea, throughout the island to the mainland of Asia.

The first reference to *Nepenthes* in Australia comes from William Carron, the botanist with the ill-fated Kennedy expedition of 1848. Carron (1849) writes of an area near the Walsh River, "By the side of the small streams running through the flat ground, I saw a curious herbaceous plant, with large pitchers at the end of the leaves, like those of the common pitcher plant (*Nepenthes distillatoria*). It was too late in the season to find flowers, but the flower stems were about 18 inches high, and the pitchers would hold about a wine glass full of water. This interesting and singular plant very much attracted the attention of all our party."

This record is interesting as *Nepenthes* has not subsequently been reported from anywhere near this area. However, Carron was writing from memory and the record is therefore by no means certain. Pitcher plants were also commented on by other explorers such as Logan Jack (Jack, 1921), but the rigors of travel in this area were such that serious botanical records were not obtained until the establishment of the settlement at Somerset by Frank Jardine in the later part of the last century. Jardine was host to many leading scientists and naturalists, including the Queensland Colonial Botanist, F. M. Bailey, and the noted painter, Mrs. Rowan, whose paintings of *Nepenthes* are to be found in 'Plant of Prey' by Rica Erickson.

The first botanical description of Australian material was by Baron von Mueller in 1866, who described *N. kennedyi.* Bailey followed with descriptions of another 10 species between 1881 and 1905. These were *N. bernaysii, N. jardinei, N. albo-lineata, N. moorei, N. alicae, N. cholmondeleyi, N. pascoensis, N. armbrustae, N. garrawayae, N. rowanae.*

These names stood until 1928 when B. H. Danser in his epic work, *The Nepenthaceae of the Netherlands Indies,* (still the standard reference on the genus), reduced all these names to synonyms of *N. mirabilis,* saying ". . . . they are nearly all mere growth forms of *N. mirabilis.*"

Nepenthes mirabilis is a plant of swamp margins and other areas which are wet for at least half the year. While it is sometimes thought of as occurring in a few separate areas such as Weipa, Tozer's Gap, the Jardine River area and near Coen Airport, it is in fact a very common plant in the northern part of the Peninsula wherever the habitat is suitable. Vast areas of swampland, almost never visited, are abundant on the east coast and *N. mirabilis* is one of the most conspicuous plants in these swamps. Apart from Carron's report, pitcher plants have apparently not been found south of Coen, with the exception of an isolated population several hundred kilometers to the south near Cairns.

The climate of northern Cape York Peninsula is strongly seasonal. Most of

Please see **NEPENTHES** p. 72.

N. mirabilis growing in swampy conditions near Bamaga, northern Cape York Peninsula.

The author with a large plant of *N. mirabilis* near Tozer's Gap.

Nepenthes mirabi

Photos by Dr. S

Habitat of *N. mirabilis* near Tozar's Gap. This area is an open sedge swamp.

The form of *N. mirabilis*, originally named *N. rowanae* by F. M. Bailey.

Male inflorescence and pitchers of *N. mirabilis*.

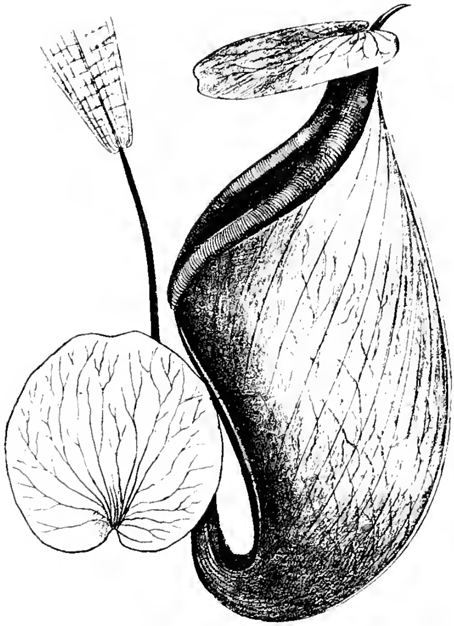
ilis in Australia

. Lavarack

Young plants of *N. mirabilis* growing sand at Tozer's Gap.

the area receives in excess of 1,400 mm of annual rainfall, but all of this falls in the period December to April. However even in the dry season the area is subject to moist south-easterly winds which maintain a high humidity throughout the year. Temperatures never fall below 15° C. over most of the area, although near Coen in the southern part (where pitcher plants are scarce) July temperature may fall to about 10° C. Day temperatures vary from a maximum of about 28° C. in winter to about 35° C. in summer.

In exposed situations which are dry during the winter, the plants are usually compact small shrubs, but in permanently wet shady swamps, they grow into long straggling vines reaching up to 10 m into the trees. Plants growing under the latter conditions usually produce very few pitchers, while those in the sun produce pitchers prolifically and, as a rule,ones that are more colorful. I have seen *Nepenthes* in several different parts of the Peninsula and.the greattest variation appears to occur in the area near the Jardine River and north to Cape York itself. The largest pitchers I saw were about 25 cm long but this was on one plant only. Most have pitchers about 8 to 15 cm long or smaller on younger plants. The form described by Bailey as *N. rowanae* is one of the most decorative, having large pitchers which are squat in shape and usually deep red in color. Some plants continually produce small pitchers less than 5 cm in length. One such plant has been growing in my glasshouse in Brisbane for about three years with no increase in size of the pitchers. Color is variable, mostly green but often with patches of red, particularly on the upper part of the pitcher. Quite often the underside of the lid is dark red. The shape is also variable from squat to elongated. Lower pitchers often are ornamented with two distinct fimbriate wings which are absent or nearly so on the upper pitchers. In the southern part of the range, and in the Cairns population, there is not a lot of variation, with



Nepenthes rowana, Bail.; (¼ nat. size); Gov't. Printing Office, Brisbane.

the pitchers mostly being about 10 cm long, relatively slender and even green in color or with the upper portion light red.

The flowering period is not entirely clear, but I have observed flowers in August and September and have collected fresh viable seed in September and December. Seedlings are common, but the plants also reproduce by natural layering as the long straggling stems put down roots and send up shoots wherever they touched the ground. Old stems eventually die and separate plants result.

In their natural habitat the plants suffer from very few pests and diseases. These are two problems facing pitcher plants on Cape York—fire and pigs. The plants survive the occasional fire which penetrates the swamps in very dry years by means of a below-ground tuber, but they cannot withstand regular yearly fires. Wild pigs often dig plants up when digging up other food plants.

Cultivation is possible in bush house

Please see **NEPENTHES** p. 75.

From
SINNESORGANE IM PFLANZENREICH
by Gottlieb Haberlandt
V. Insectivores: *Aldrovanda vesiculosa*

Translated by Carla R. Powell
Department of Chemistry and Foreign Languages
Lebanon Valley College, Annville, PA 17003

Editor's note:

Professor Dr. Gottlieb Haberlandt of the University of Graz published Sinnesorgane im Pflanzenreich: sur Perzeption mechanischer Reize *in 1901. A second edition with important additions including some major observations on the anatomy of* Dionaea *was published in 1906 by the Verlag von Wilhelm Engelmann in Leipzig, Germany. No English translatioon of this classic work exists. Some of Professor Haberlandt's observations are still the best information available on the subject, but because of the early date of the work and the lack of a translation they are often overlooked by the English speaking authors.*

We plan now to present the first translation into English of Haberlandt's chapter on insectivorous plants from the second edition of Sinnesorgane. *The following section on* Dionaea *and one on* Drosera *will follow. These portions of* Sinnesorgane *were translated by Carla R. Powell, a chemistry and German student at Lebanon Valley College. Dr. James W. Scott of the Lebanon Valley College Department of Foreign Languages supervised her work. Dr. Stephen E. Williams of the Lebanon Valley College Department of Biology read the text for technical accuracy and added annotations, some included within the text in square brackets, and the rest in the form of numbered endnotes to point out some current developments and to clarify the text. Dr. Yolande Heslop-Harrison of Aberystwyth, Wales, has contributed to the work with her useful comments.*

As Auge de Lassus (1861) first discovered, and as B. Stein (circa 1876) later rediscovered, the leaf blades of these aquatic plants belonging to the family Droseraceae are sensitive to contact. The edges of the leaf blade curve upward along the axis of the midrib; the portions adjacent to the midrib bulge outward, while the upper portions close to form a cavity in which small aquatic animals are caught and digested. Tactile bristles occur on the upper side of the midrib, but also on the adjoining parts of the leaf blade [fig. a]. These were discovered by Ferd. Cohn (1875), who very briefly described their anatomical structures as follows: "In addition, the inner surfaces bear long, colorless, articulated hairs consisting of double or single rows of cells, in which longer, internodal cells alternate with short nodal cells." Regarding their function he says the following: "The analogy with *Dionaea* suggests that those multicellular, articulated hairs which occur sparsely on the inner sides of the leaf blade, but in a thick beard over the midrib, receive a stimulus from contact with small aquatic animals, and transmit it out to the leaf surface."

Darwin (1875) also had little to say about the tactile bristles of *Aldrovanda.* According to him, they differ from the *Dionaea* tactile bristles in that they are colorless, and have "a middle, as well as a basal articulation." This is, however, incorrect. There is only one articulation [Plate VI, fig. 1]. It is Darwin's view that this articulation is important because it prevents the tactile bristles, in spite of their length, from being broken when the leaf blade closes.

The detailed structure of the tactile bristles was not discussed by Goebel (1891). He simply emphasized the thinness of the walls of the hinge cells. In the second edition of my *Physiologishen Pflanzenanatomie*[1] I have presented a more exact and illustrated description of the structure of these organs (pp. 480, 481). The following remarks repeat and enlarge upon these views.

Strictly speaking, the tactile bristles

Please see **ALDROVANDA** p. 76.

Drosera zoneria

D. zonaria in flower. Photo by Allen Lowrie.

D. zonaria showing the concentric arrangement of rosette leaves. Photo by K. W. Dixon and J. S. Pate.

N. mirabilis in Australia continued

Photos by Dr. P. S. Lavarack

A fairly typical form of *N. mirabilis* from near Massy Creek on Cape York Peninsula.

N. mirabilis in flower at Tozer's Gap.

Drosera zonaria in Flower

by Allen Lowrie
6 Glenn Pl., Duncraia WA 6023
Australia

In February, 1980 I planted out all my tuberous *Drosera* that had been stored dry over the summer period in plastic bags. The only reason they were planted out then was because the majority of tubers had started to grow.

Tuberous *Drosera* may have a built in time clock. The tubers stored dry in plastic bags — in the house — in the dark at even temperature were just as advanced as those tubers that were left in pots in the glasshouse.

About May, 1980 some of the tuberous *Drosera* were starting to appear in their pots. Among them to my surprise and delight was *D. zonaria* sending up a flower spike. As most of you know, this event for *D. zonaria* is very rare. Up to this day few people have had the opportunity to observe the whole process day by day.

The flower spike, complete with unopened buds, burst through the soil surface. It took only a few days for the flower spike to reach its full height of 4 cm; then, each day a flower opened. On one particular hot day 3 flowers opened at one time. The flower shape and parts are very similar to *D. erythrorhiza,* except the perfume of *D. zonaria* is stronger and sweeter to the nose. Of the 20 *D. zonaria* tubers planted in February, 1980, three of them flowered.

When all the flowers had faded, the typical *D. zonaria* plant rosette appeared on the flower spike at ground level. As the rosette grew larger it pushed the flower spike over to one side, to the point where it was flat on the soil surface when the rosette had reached full size.

Maybe the reason *D. zonaria* flowered so well was their storage in plastic bags — in which they may have created their own ethylene gas. K. Dixon's studies show that ethylene gas produced by bush fires stimulates mass flowering of some Western Australian tuberous *Drosera.* All the *D. erythrorhiza* tubers I stored the same way as *D. zonaria* flowered. This is one tuberous *Drosera* that needs a bush fire to produce mass flowering.

Next season I intend to store tuberous *Drosera* the same way but this time I plan to introduce an ethylene gas producing agent. Perhaps this will make all my *D. zonaria* flower at the same time.

NEPENTHES continued from p. 72

conditions in the tropics or in a heated glasshouse in temperate regions. The plants should be kept evenly moist and humid at all times and should preferably be grown in a strong light. Night time temperatures above 15° C. are best for good growth and the plants must be sheltered from winds at all times. They do well in a variety of mixtures but most include peat moss, sphagnum moss, perlite and coarse sand. The medium should remain moist but not soggy after watering.

Propagation from plants in cultivation is best achieved by cuttings as the production of seed requires a male plant and a female plant to be in flower at the same time.

REFERENCES

Bailey, F. M. (1901) "The Queensland Flora" IV. The Queensland Government, Brisbane.

Carron, W. (1849) "Narrative of an Expedition undertaken under the direction of Mr. Assistant Surveyor E. B. Kennedy etc." Kemp and Fairfax, Sydney. p. 48.

Danser, B. H. (1928) "The Nepenthacae of the Netherlands." Indies. Bull. Jard. Bot. Buitenz., Ser. III, Vol. IX.

Please see **NEPENTHES** p. 76

ALDROVANDA continued from p. 73. occur, not on the midrib of the leaf, which is occupied by compact, patelliform glands [See the small gland at the base of the tactile hair; Plate VI, fig 1.], but rather toward both sides of the leaf. They do not form a thick beard, however, as Cohn indicates. I never counted more than 18 to 20 bristles along the midrib. They occur only sparingly on the surface of the part of the leaf blade which forms the bladder. They are more numerous on the edge of the leaf, where I counted 7 to 9 bristles on either side. In all then, a leaf exhibits no more than about 30 to 40 tactile bristles.

In their lower parts, the 0.45 to 0.6 mm long tactile bristles are composed of four, and in the upper parts of two rows of cells occurring side by side, which form 5 to 7 tiers (Plate VI, fig.1). The lowest tier is short-celled and forms a pedestal. Darwin erroneously considered it to be a basal hinge. But its outer walls are only slightly, if at all thinner than those of the tier above it (fig. 9). Neither does this footpiece exhibit the remarkable deviations in chemical and physical properties which are characteristic of the true "hinge" of the bristle. The bristle is inserted into the leaf surface at an angle. The colorless footpiece is separated from the chlorophyll-containing "epidermis" by very delicate, slightly bowed walls, which have numerous, though faint, fissure-shaped pits. Most cells of the footpiece contain some fine-grained starch.

One to three tiers of elongated cells occur on the short-celled pedestal, whose outer walls are very thick, while the radial walls remain delicate. On top of this follows a remarkably short-celled tier, whose cells are only approximately twice as long as wide, and have thin outer walls. This tier represents the sensitive part, the hinge of the bristle. The upper tiers finally are long-celled, and have thickened outer walls—of course, the thickening here, is for the most part—not as strong as in the lower parts of the bristle, with the exception of the section bordering immediately on the hinge. The two top end cells usually separate slightly at the tip of the bristle.

The hinge has two cells, or sometimes four as a result of a cross-division (Plate VI, fig. 2). The adjoining elongated cells arch forward slightly on both sides toward the hinge cells. The thinness of the outer walls of the hinge is all the more noticeable because of the contrast with the walls of the elongated cells bordering directly on them, which are usually somewhat thicker than the rest. The hinge is restrained on both ends by a tough ring of wall material, which prevents excessive deformation of the cross-sectional form of the hinge when it is bent [See the thickened parts of the wall at the top and base of the cells in the center of Plate VI, fig. 2.]. The thin outer walls of the hinge cells are covered by a very delicate cuticle, which extends to cover the entire surface of the bristle in the same fashion. Only in the case of the elongated, rigid cells and the footpiece do the parietal layers under the cuticle consist of relatively pure cellulose. Here they stain a beautiful shade of violet with zinc chloride-iodine, without significant swelling. However, the delicate outer walls of the hinge cells swell tremendously and exhibit pulvinate thickening, but remain completely colorless (fig. 4). Such mucilaginous swelling of the outer wall occurs easily, in any case. One can frequently observe it on old leaves without the addition of reagent, particularly toward the end of the vegetative period. The swelling regularly occurs during treatment of the brisles with Javelle water[2] (fig. 3). The huge

Please see **ALDROVANDA** p. 83

NEPENTHES continued from p. 75.

Jack, R. L. (1921) "Northmost Australia" 2 Vols. Simpkin, Marshall, Hamilton, Kent and Co., London.

Mueller, F. (1866) "Fragmenta Phytographiae Australiae" 5.

Fig. a

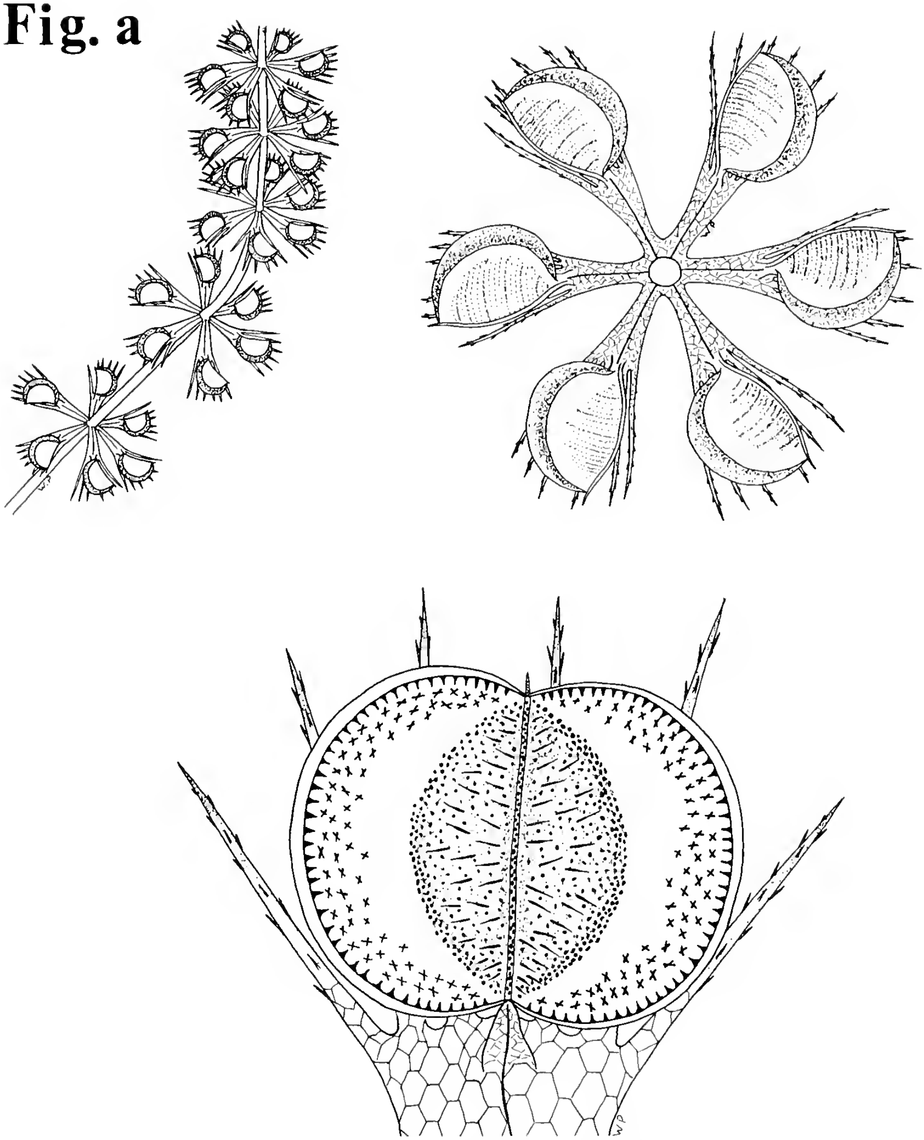
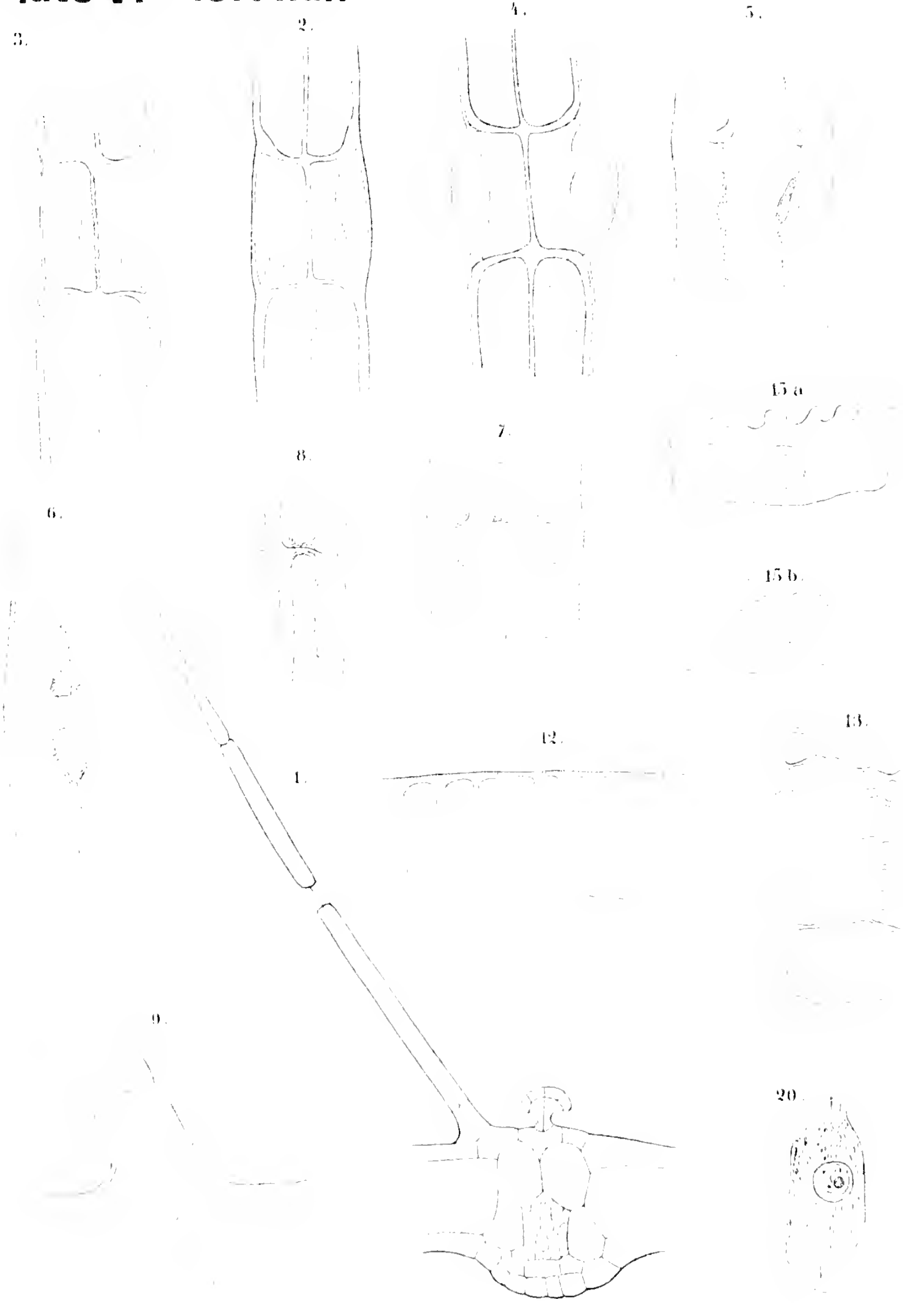


Fig. a. *Aldrovanda vesiculosa.* Upper left—a portion of a stem near its upper end illustrating the positioning of whorls of leaves. Upper right—an enlarged view of a single whorl of leaves illustrating the position of undisturbed traps on its surface. Lower center—a blade of a single leaf illustrating the various surface features of the interior of the trap. The left lobe (*free side lobe*) of the trap is illustrated in an unnaturally wide open position in order to allow a better view. The width of the trap illustrated here would be about 4 mm when measured at the point of its greatest breadth. The *tactile bristles* mentioned by Haberlandt occur in the central part of the leaf where they appear as lines. The *patelliform glands* which are also in this region appear as dots. Both of these structures are illustrated by Haberlandt in Plate VI-Fig. 1. The cross-shaped glands called *cruciform glands* and the small teeth on the edges of the lobes called *marginal spines* were not illustrated by Haberlandt in this book which deals only with sensory structures. These drawings are by Mr. Wayne Perry of Palmyra, PA and were not a part of Haberlandt's work. Detailed descriptions of the leaf structure can be found in Lloyd *Carnivorous Plants,* 1942.

Plate VI left half



See explanation on opposite page.

PLATE VI – Explanation of Illustrations

Figs. 1-9: *Aldrovanda vesiculosa.*

Fig. 1.	Cross-section through the midrib of the leaf with a tactile bristle. X140.
Fig. 2.	Sensitive hinge of a live tactile bristle. X480.
Fig. 3.	The same after treatment with Javelle water; the delicate outer walls of the hinge cells are greatly swollen.
Fig. 4.	The same after treatment with $ZnCl_2$-I_2 solution. The varying intensity of the violet coloring is indicated by the varying gray tints. The swollen outer walls of the hinge cells remain colorless.
Figs. 5-7.	Plasmodesmata between the hinge cells and the mechanical cells of the tactile bristle bordering on the base. After treatment with I_2-KI solution and dilute sulfuric acid and staining with toluidine blue. X approx. 1200.
Fig. 8.	The same with much less swelling of the transverse wall.
Fig. 9.	The base of the tactile bristle. X530.

Figs. 12 and 13: *Drosophyllum lusitanicum.*

Fig. 12.	Cross-section through two cells of the epidermal glandular layer of a stalked gland. The cuticle has fine pores. After treatment with Javelle water. X approx. 600.
Fig. 13.	Surface view of two cells of the epidermal glandular layer. After treatment with Javelle water.

Fig. 15: *Drosera rotundifolia.*

Figs. 15a and b.	Isolated protoplasts of the lateral glandular cells of a parietal tentacle as seen from the side. On the upper side a row of plasma appendages which project into the peripheral pits. After swelling of the membrane with dilute sulfuric acid. X approx. 900.

Fig. 20: *Drosera longifolia.*

Fig. 20.	Isolated protoplast of an apical glandular cell. After treatment with dilute sulfuric acid and staining with toluidine blue. X approx. 1000.

EXCLUSIVE continued from p. 68.
Hydnophytum is also an epiphyte, it is quite likely that it materially benefits from its insect meals. Ironically, *Nepenthes bicalcarata* is also an ant-plant as its pitcher-supporting tendrils are hollow and provide shelter for the ants which burrow into them.)

Discussion & conclusions

The likelihood of discovering carnivory amongst many more plant species than currently recognised looks very promising. Although this article has only made brief mention of sticky and pitcher traps, there are many other promising candidates with other types of traps worth considering, many of which were included in Lloyd's introductory chapter in his book (Lloyd, 1942).

Yet since the publication of Lloyd's book, only *one* new genus, *Triphyophyllum*, has been officially added to the list of plant carnivores (Green, Green and Heslop-Harrison, 1979). Why has so little progress been made on this front?

One of the reasons is probably the uncertainty of what *exactly* a carnivorous plant is. The main criteria may be as follows (although there is at least one exception to every point):

1. Attracts animals to a trap.
2. Traps and kills the animal victims.
3. Secretes a digestive juice onto the prey.
4. Absorbs the products of digestion into the plant.
5. The plant derives material benefit from its animal nutrition.

Another reason for not investigating more species is that proving carnivory, as outlined in the above criteria, requires considerable time, facilities, and money. For example, absorption of digestion

products is best shown by using radioactively labelled compounds fed directly or indirectly (through animals) into the plant, and this technique needs stringent safety facilities as well as sophisticated apparatus.

Perhaps there is also a reluctance amongst enthusiasts to extend the 'status' of carnivory too far. After all, the conventional carnivores were largely established by scientific investigation over 50 years ago — why should we spend time and money on testing out completely new species?

To my mind the most exciting results could come from investigating crop plants. Darwin made mention of the sticky glands of *Nicotiana tabcum* (tobacco), but there are other surprising possibilities, amongst them the sticky leaf glands of a wild tomato *Lycopersicon hirsutum* and of some species of wild potato (e.g., *Soolanum tuberosum*). Both the tomato and potato glands have been extensively studied, but surprisingly only their insecticide activity has been sought after (e.g., Williams *et al.*, 1980, Gibson, 1978 respectively).

Given the chance, we might be on the threshold of a renaissance in carnivorous plant research with prizes as every bit as great as those that Charles Darwin and his contemporaries grabbed. Above all we must keep open minds, perhaps even regarding these plants as having *degrees* of carnivory, rather than *in toto*.

References

Barber, J. T. *Capsella bursa-pastoris* seeds. Are they carnivorous? Carniv. Pl. Newsletter 7:39-42 (1978).

Christy, M. The common teasel as a carnivorous plant. J. Bot. 61:33-45 (1923).

Darwin, C. *Insectivorous Plants*. J. Murray, London (1875).

Gibson, R. W. Resistance in glandular-haired wild potatoes to flea beetle. Am. Potato J. 55:595-599 (1978).

Green, S., Green, T. L. and Heslop-Harrison, Y. Seasonal heterophylly and leaf gland features in *Triphyophyllum* (Dioncophyllaceae), a new carnivorous plant genus. Bot. J. Linn. Soc. 78:99-116 (1979).

Lloyd, F. E. *Carnivorous Plants*. Wlatham, Massachusetts (1942), reprinted by Dover Publications, (1976).

Mameli, E. Richerche anatomiche, fisiologiche e biologiche sulla *Martynia lutea* Lindl. Atti. Ist. Bot. dell'Universita di Pavia, Series II, 16:137-188 (1916).

Mameli, E. and Aschieri, E. Richerche anatomiche e biomiche sul *Lychnis viscaria*. Atti. Ist. Bot. dell'Universita di Pavia, Series II, 17:119-129 (1920).

Rickson, F. R. Absorption of animal tissue breakdown products into a plant stem — the feeding of a plant by ants. Am. J. Bot. 66:87-90 (1979).

Schuster, R. M. *The Hepaticae and Anthocerotae of North America East of the Hundredth Meridian. Vol. 1.* Columbia Univ. Press, New York and London (1966).

Watkins, E. V. *The Structure and Life of Bryophytes*, 3rd edition, p. 40. Hutchinson, London (1971).

Williams, W. G., Kennedy, G. G., Yamamoto, R. T., Thacker, J. D., Bordner, J. 2-tridecanone: a naturally occurring insecticide from the wild tomato *Lycopersicon hirsutum* f. *glabratum*. Science 207:888-889 (1980).

Zambelli, E. Ricerche anatomofisiologiche sulla *Petunia violacea* e sull *Petunia nyctaginiflora* come piante insettivore. Atti. Ist. Bot. dell'Universita di Pavia, Series IV, 1:75-87 (1929).

Van Oye, P. De micro fauna en flora der bladtrechers van Bromeliaceae. Natuurwetenshapp. Tijdschr 5:179-182 (1923).

Additional Note: If anyone has photos of any of the potential carnivores mentioned in this article or others also likely to be carnivorous, I would be *very* grateful to have loan of them to make copies. All material will be promptly returned and remuneration made for costs.

* If anyone would care to volunteer translating further parts of the papers I would very much like to hear from them!

Review of Recent Literature

Crow, G. E., et. al. 1981. Rare and endangered vascular plant species in New England. Rodora 83:259-299.
Among the CP evaluated by the authors as rare, or threatened and endangered, or both (E/T), are the following (states are new official two-letter abbreviations). *Drosera anglica* and *D. linearis*, found so far only in ME, are E/T, and their endangered status is of national significance in that there is a decrease in numbers and stations throughout the U.S. range. *D. filiformis* is rare in MA, RI, and CT, but is not E/T. *Pinguicula vulgaris* is listed from NH and VT only, E/T in the region only. *Utricularia biflora* is rare (not E/T) and is found in MA and CT. *U. fibrosa* is E/T for the region and found in MA and CT. Finally, *U. subulata* has been reported rarely to the extent of E/T, but there is taxonomic uncertainty of the specimen. (DES)

Dwyer, J. D. 1981 A list of the Dicotyledoneae of Belize. Rhodora 83:161-236.
Among the lengthly list of species found in this Central America country are the following CP: *Drosera capillaris, D. intermedia, Genlisea filiformis, G. luteoviridis, Utricularia adpressa, U. areola, U. cornuta, U. erectiflora, U. fimbriata, U. foliosa, U. guianensis, U. hispida, U. hydrocarpa, U. juncea, U. juncea* f. *minima, U. macerrima, U. mixta, U. obtusa, U. peckii, U. pinetorum, U. purpurea, U. pusilla, U. resupinata, U. simulans* and *U. subulata.* (DES)

Fahn, A. 1979. Chapter 6, "Glands of carnivorous plants," in *"Secretory tissues in plants,"* Academic Press, London, New York, and San Francisco, pp. 129-146.
A pretty good, illustrated review of secretory glands in all major genera of CPs. The review seems a bit dated in checking the reference dates, but this is likely due to the explosion of papers on this subject in the last 4-5 years and the normal lead time delay in publishing material in a book. A good baseline starting point for groundwork and references relatively current to about 1975, and then more current material such as reviewed in recent issues of CPN to be added by the student. (DES)

Fineran, B. and Lee, M. The organization of the epidermal glands on the trap and other organs of the bladderwort *Utricularia monanthos.* Protoplasma 103(1):17-34 1980.
The authors examined the ultrastructure of mature dome-shaped glands which cover the entire plant. The glands are apparently responsible for secreting water, with those on traps being particularly active during the resetting of the organ.

Kisha, Jennifer S. 1981. Observations on the trapping of the whitefly *Bemisia tabaci* by glandular hairs on tomato leaves. Ann. Applied Biol. 97:123-127.
While no more "carnivorous" than similar trapping by other glandular plants (e.g., *Silene* ssp.), the paper is interesting since the trapping of pests such as whiteflies and aphids in mired glandular secretions is of benefit to the plant in eliminating the activities of the insects, including oviposition. Attempts are being made to breed domestic tomato varieties with their more glandular wild relatives to incrase this insect immobilizing factor for economic reasons. (DES)

Kral, R. 1981. Further additions to some notes on the flora of the southern states, particularly Alabama and middle Tennessee. Rhodora 83:301-315.
In this paper, the author lists new finds for the area covered (previously unreported) with a brief paragraph or

so of discussion. One CP is mentioned, namely *Utricularia floridana*, usually confined to FL and GA, and found for the first time in Alabama in Covington County. (DES)

Lysek, G. and Nordbring-Hertz, B. 1981. An endogenous rhythm of trap formation in the nematophagous fungus *Arthrobotrys oligospora*. Planta 152:50-53.
This interesting article was sent to us by Stephen Williams and represents a significant contribution to the apparently lean literature on carnivorous fungi. Actually, consultation of the references in this paper indicate many physiologic papers by the junior author and some others on trap formation and function and should be consulted by interested parties. This paper indicates that trap formation under constant conditions and stimulus with prey occurs in peak bursts of 42 hours, independent of photoperiod and many other factors. However, lowering the temperatures to certain critical levels caused the peaks of trap formation to approach and finally overlap. (DES)

Muller, J. 1981. Fossil pollen records of extant angiosperms. Bot. Rev. 47:1-145.
Among the presently extant taxa of angiosperms whose pollen has been found in deep drill cores (usually in bog or peat areas) are: *Aldrovanda* (p. 59), *Drosera* sp. (p. 59, New Zealand); and *Droserapolis* from central Europe, similar to *Drosera* pollen, *Dionaea* (p. 59, *central Europe*!), *Nepenthes* (p. 59, Borneo), *Utricularia minor* (p. 97, Mexico, Senegal and Georgia). Pertinent pages should be consulted for detail. Not many CP pollens have been found preserved in such palynological studies since the pollen exines of nearly all CP are quite fragile. These skeleton results are intriguing. (DES)

Nelson, E. Charles and Seaward, Mark E. D. 1981. Charles Darwin's correspondence with David Moore of Glasnevin on insectivorous plants and potatoes. Biol. Jor. Linn. Soc. 15:157-164.
This is a fascinating recounting of some interesting CP history in letters only recently discovered. David Moore (1807-1879) was horticultural director of Glasnevin Botanical Gardens (Dublin) and supplied Darwin with much of the latter's CP material for research. Among the more interesting things we learn is the difficulty Kew had in keeping *Drosophyllum* (Moore in Dublin was able to supply it), the experience that *Pinguicula grandiflora* lent itself easily to continuous horticulture at Glasnevin (requiring little care) while *P. vulgaris* required yearly replacement, that Moore was one of the first breeders of *Sarracenia* hybrids and that *S.* × *moorei* was named for him (his earliest hybrid winning first prize at a show) and he named *S.* × *popei* after his head gardener. Those with a historical bent will find the complete article fascinating. (DES)

Taylor, David. 1981. Tender traps. Greenhouse 5:38-41.
This article appears in a relatively new British magazine devoted to greenhouse growing. The article is an excellent summary of CP in the greenhouse with many specific hints and comments on cultivation. The article has some excellent photos, including a cover color, five interior color and three black and white, all of the author's vigorous and well-grown plants. (DES)

Wexler, Jerome. Secrets of the Venus' Fly Trap. Dodd, Mead & Co., Inc.
In this book, the black and white photographs are very nice. I particularly like the ones of the rhizome, seeds, seedlings and fruits. I think the book is excellent for young people who start with nothing but an interest in a plant that "eats" animals. It leads them through a few "what if" observations and experiments that hopefully they will carry further and

WANT ADS

When submitting Want Ads, please be sure to print clearly for best results and to eliminate mistakes. Please circle the correct letter before each item (Want, Trade, Sell or Buy). Want ads are limited to carnivorous plants, terrariums, greenhouses and moss. There is a charge of ten cents per item, with no limit to the number of items you may submit per issue.

Send coin or check to:
Arboretum, Want Ads
California State University
Fullerton, CA 92634

Dow Airen (12 Ross St.; Yeppoon; Qld 4703; Australia). [T] only *N. pervillei* seedlings of ca. 40-75 mm diam. for other *Nepenthes* except *N. alata, ampullaria, gracilis, gracilima, hirsuta, kampotiana, mirabilis, rafflesiana, thorelli, veitchii, ventricosa, × bossiense, × coccinea, × dormanniana, × dyeriana, × hookeriana, × wrigleyana, × ventrata.*

Ron Galiardo (1216 Cooper Dr.; Ralieigh, NC 27607). [B] *Heliamphora* spps., *Byblis gigantea* (plants), *Drosera gigantea, D. schizandra, D. auriculata, D. peltata, D. capensis* crestate, *D. prolifera, D. whittakeri, D. × hybrida, D. drummondii, D. petiolaris, D. linearis, D. anglica, D. platypoda, Cephalotus, Nepenthes rafflesiana, N. ampullaria, N. alata* large plants, *Polypompholyx, Sarracenia oreophila, S. rubra jonesii,* large *Darlingtonia.*

Marabini Johannes (St.-George-Str. 62; D-8552 Hochstadt/A; West Germany). [WT] *Heliamphora tatei, H. tyleri, Nepenthes clipeata, N. hirsuta, N. inermis, N. peniculata, N. rajah, N. edwardsiana, N. vieillardii, N. tobaica, N. truncata, N. veitchii.* [T] ca. 100 CP species available.

ALDROVANDA continued from p. 76.
mucous swellings bulge either inward toward the cell lumen, or toward the outside. If they bulge outward, the cuticle is stretched so tightly that it is often separated from adjacent parts of the elongated cells. This chemical transformation is accompanied by great flexibility and elasticity of the outer walls of the hinge. They are extraordinarily easily crumpled; their cuticle has a strong tendency to collapse in transverse folds.

(to be continued)

Literature Review
continued

thus gives them some of the real spirit of scientific investigation while it teaches them a good deal of botany. It is an empirical or "hands on" approach which is the best way to teach science and the only way to do science.

On the negative side I have only a few comments. First I hope that any future printings will have page numbers. Some parts of the book may be referred to in the future by others, particularly the parts on growing plants and the lack of page numbers will make this difficult. Secondly, not all of the experiments have an emphasis which leads people to understand the plant as it functions in nature and I think the role of chemical stimuli in inducing and maintaining narrowing is understated, but these are minor points because the book is presented as a series of experiments. The results for the work that was done are there and the young reader can hopefully do more experiments of his own. It is more important to get young people asking questions and doing experiments than it is for them to gain a sophisticated understanding of the Venus' flytrap. (Stephen E. Williams, Dept. of Biology, Lebanon Valley College, Annville, PA 17003)

Zachariah, K. 1981. Chemotropism by isolated ring traps of *Dactylella doedycoides*. Protoplasma 106:173-182.

New work with carnivorous fungi continues apace! In this work, the author placed uninflated ring traps of the above fungus species on agar near dead or moribund nematodes. Some rings were then induced to inflate with chlorobutanol. All rings produced hyphae which grew towards the prey, eventually differentiating into feeding hyphae which digested the carcass. More very useful references at the end of paper. (DES)

The form of *N. mirabilis* which has recently been found south of Cairns, Queensland, Australia.

Photo by Dr. Peter S. Lavarack